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TRENDS IN THE ABUNDANCE AND DISTRIBUTION OF SEA OTTERS (*ENHYDRA LUTRIS*) IN BRITISH COLUMBIA UPDATED WITH 2013 SURVEY RESULTS

Photo by L. Nichol

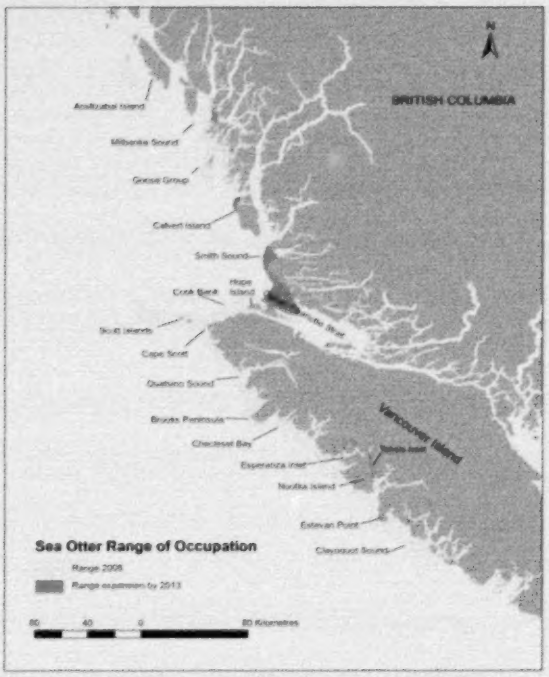

Figure 1. Map of sea otter range in British Columbia.

Context

The Sea Otter (Enhydra lutris) has been listed as a species of Special Concern under SARA since 2009. The SARA Management Plan for the Sea Otter identifies the need for regular surveys to support conservation of the species in Canada. Assessment of trends in abundance and population growth is dependent on a time series. The Sea Otter Management Plan identifies the undertaking of "annual surveys of the Sea Otter population in index areas, areas of range expansion, and other portions of their range as needed, as well as a total population survey every five years, to monitor population trends and distribution". In 2013, a range-wide boat survey was completed in British Columbia. The results provide an index of abundance for 2013 and contribute to an analysis of population growth trends to provide requested science advice about growth trends and distribution in BC. This Science Advisory Report is from the Annual Meeting of the National Marine Mammal Peer Review Committee (NMMPRC) held in Ottawa October 20-24, 2014. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Canada

SUMMARY

- BC sea otter surveys provide direct counts that represent an index of population abundance and allow for analysis of trends in population growth. Data collected also provide fine-scale detailed information about the distribution of sea otters, locations of rafts by sex and the timing of range expansion events.
- As of 2013, population growth and range expansion continue to follow positive trends in British Columbia (BC), but show characteristics of density-dependent growth typical of sea otter populations. Annual rates of increase are lowest in long-occupied areas, presumably reflecting density dependence. However, in more recently occupied areas growth is still exponential, with rates of annual increase in excess of R_{max} (17-25% per year), which is the maximum rate of increase for this species in the absence of density dependent factors, and due to immigration from other areas.
- During a range wide survey in 2013, 6,754 sea otters were counted (5,612 in the Vancouver Island region and 1,142 in the central mainland coast region).
- On Vancouver Island the annual rate of increase from 2004 to 2008 was 7.1% per year (SE = 1.05) and from 2009 to 2013 it was 6.8% per year (SE = 1.20). In the previous assessment, growth on Vancouver Island was estimated from a single exponential growth curve and a rate of 8.4% per year was estimated for the period 1995 to 2008. The lower rate in this assessment reflects the contribution of density-dependent growth in the long-occupied portions of Vancouver Island, detected by fitting population growth models to sub-regional time series of survey data.
- On the central mainland coast, the annual rate of growth was 4.2% per year (SE = 1.62) from 2004 to 2008 and then 12.6% per year (SE = 1.65) during 2009 to 2013. The much higher rate of growth in the most recent period reflects the contribution of sub-regions that have only been occupied since 2007, where growth is best described by exponential growth models.
- Since 2008, range expansion, signified by the observed presence of a raft of male sea otters in spring or summer in a previously unoccupied area, has occurred primarily in Queen Charlotte Strait and the adjacent mainland coast. On the central mainland coast, range expansion to Calvert Island occurred in summer 2013.
- Analysis of population growth trends by sub-regions made possible the use of a larger data set of surveys and the examination of patterns of growth within the population associated with occupation time in this density dependent species. However, sub-regions do not represent distinct population units.
- There are no estimates of the size of the sea otter population in BC prior to the maritime fur trade that commenced in 1778 and ended with the extirpation of the species in BC by 1930. However, even incomplete historical records, which only enumerate pelt landings over certain periods and for certain areas, suggest a much larger population than today.
- Habitat models suggest that the population is well below coast wide carrying capacity and is still distributed in only a portion of its historic range in BC.

BACKGROUND

Species biology

The sea otter, *Enhydra lutris*, is the only member of the genus *Enhydra* and three subspecies are recognized. *Enhydra lutris kenyoni*, which ranged historically from Oregon to the Aleutian Islands, is the subspecies in Canada. Unlike other marine mammals, sea otters have little body fat to provide insulation, instead they rely on a layer of air trapped in their dense fur for insulation and they maintain a high metabolic rate to generate heat. Sea otters groom frequently to maintain the integrity of their fur and its ability to hold a layer of air.

Sea otters are sexually dimorphic. Adult males, in BC, can reach 50 kg in weight and growth to a length of 150 cm, whereas adult females weigh up to 36 kg and grow to 140 cm in length. Sea otters spend their entire life on the oceans and rarely come ashore. They are gregarious and are often observed resting in floating aggregations called rafts that can number over 200 animals in BC, but they segregate by sex and form male rafts and female and pup rafts. The sea otter has a polygynous mating system and territorial males leave male raft areas and established breeding territories around female raft sites.

Females attain sexual maturity at 2 to 5 years. Males reproduce at 5 to 6 years of age, although they may be sexually mature earlier. Females have a higher survival rate than males and live 15 to 20 years, compared to 10 to 15 years for males. Mating and pupping occur year-round, although there are distinct peaks in pupping in spring noted in some populations including BC. Females give birth to a single pup at approximately 1-year intervals. At birth, pups weigh 1.7-2.3 kg and are up to 60 cm in total length. Maternal investment is high, as the pup remains dependent on its mother for 5 to 8 months.

Sea otters live in nearshore coastal habitats and are most commonly found within the 40-metre depth contour. Sea otters feed on benthic invertebrates, which they collect from the sea floor by diving, and they require frequent access to foraging habitat in subtidal and intertidal habitat to meet their energetic needs. The extent of sea otter habitat is thus set by the limits of their preferred foraging depth, with the result that most sea otters are within 1 to 2 km of shore unless shallow areas extend further offshore.

Within this relatively narrow nearshore band, sea otters are non-migratory and occupy small overlapping home ranges throughout their lives. Territorial male home ranges can be 4 to 11 km^2, whereas female home ranges vary from a few to 24 km^2. Rafts of sea otters form habitually in the same location and are often associated with particular reefs and kelp beds. The aggregating behaviour of sea otters results in a clumped distribution in British Columbia. Sea otters primarily occupy coastal areas exposed to the open Pacific, as opposed to protected coastal waters. Along the exposed coast, sea otters are found particularly along shorelines characterized by jagged coastlines with clusters of small islets and reefs and shallow variable depths.

Sea otter populations, throughout their range in the North Pacific, were driven to the brink of extinction as a result of commercial hunting for their pelts that began with the maritime fur trade in the late 1700s. In BC, the sea otter population was extirpated by 1930. In an effort to re-establish the species in Canada, 89 sea otters were reintroduced in three translocation efforts to Checleset Bay, Vancouver Island from Alaska in 1969, 1970 and 1972. During the same period, sea otters were reintroduced to Southeast Alaska and to Washington state where they had also been extirpated early in the 20th century.

Following the successful reintroduction of sea otters to BC, Washington and Southeast Alaska, sea otter populations in these areas grew at rates between 17 to 25% per year. In BC, the

growth rate on Vancouver Island from 1977 to 1995 was estimated to be 19.0% per year, but slowed thereafter to 8.4% per year to 2008 (Watson *et al.* 1997; Nichol *et al.* 2009). Sea otter population growth is density dependent and food is the limiting factor. High rates of population growth in the early years, following successful establishment of re-introduced animals, are presumed to represent maximum rates (R_{max}) of increase for the species in the absence of food limitations. With time, growth slows as the population approaches carrying capacity, as a result of increased mortality and emigration, caused by food limitation that offset births and immigration.

In the BC, where the sea otter population continues to recover, sea otter distribution is explained by patterns of both population growth and range expansion events. Range expansion in a growing population is triggered by population density in the occupied range. The periphery, or frontal edge of the occupied range, tends to be occupied by male rafts. The appearance of a male raft in a previously unoccupied area during spring /summer is considered, for population assessment purposes, to signify the first phase of range expansion. In subsequent years, rafts of females are observed to form in the new area.

ASSESSMENT

Methods

From 1977 to 1988, surveys were made mostly from fixed-wing aircraft. Since 1988, a standardized survey approach has been used to survey by small boat, although during the period 2001 to 2004 counts from helicopter were also made. These were compared to small boat counts to assess the suitability of helicopter surveys, as an alternative approach to count sea otters, given the challenge of maintaining survey effort as the sea otter's geographic range expanded in BC (Nichol *et al.* 2005). By boat or by helicopter, the survey method is a direct count of sea otters in their known range. The range is surveyed following the same routes, using consistent methods with the same observers or observers with comparable experience among surveys. The resulting counts provide an index of abundance and data with which to calculate trends in population growth. The survey data also provide fine-scale, detailed information about the distribution of sea otters, locations of rafts by sex and the timing of range expansion events.

Following successful reintroduction, the BC sea otter population has been surveyed at 1–3 year intervals since 1977, although not all of the range was surveyed in a given year. Surveys of the entire occupied range have most recently been completed in 2004, 2008 and 2013. In the intervening years, surveys of key areas were made, particularly of areas near the edge of the known range to monitor range expansion. In addition, the centre of the sea otter range on Vancouver Island, Checleset Bay to Kyuquot Sound, was surveyed annually. In 2013, the range wide survey was made from small boats, although there was an offshore transect added and surveyed from the Canadian Coast Guard ship, *Tanu*, over Cook Bank, off northern Vancouver Island.

For population assessment purposes, two distinct regions are defined that encompass all coastal areas surveyed. The Vancouver Island region includes the entire occupied range on Vancouver Island, as well as Queen Charlotte Strait and the adjoining portion of the mainland. The Vancouver Island region includes Checleset Bay, where sea otters were reintroduced in 1969-72, and thus where sea otters have been established for the longest time. The second region, called the central mainland coast, includes the coastal waters from Calvert Island north to Aristazabal Island. The central mainland coast region includes the Goose Group, where a raft of sea otters was first reported in 1989 (Figure 1).

To assess trends in population growth within these two regions, annual survey counts were grouped into sub-regions to facilitate analysis of sub-regional patterns of population growth. Sub-regions, however, do not represent distinct population units, but do served to reveal patterns of growth in relation to occupancy time. Time series of survey counts within sub-regions were fitted with two alternative growth models using Maximum Likelihood methods. The models evaluated were for exponential and for logistic population growth, with a discrete 1-year time step. The Akaike Information Criterion was used to select the most parsimonious model for each sub-region. An annual finite growth rate was estimated for each sub-region for two 5-year intervals, 2004 to 2008 and 2009 to 2013. An overall annual growth rate for each of the two regions was also estimated to facilitate comparison with past population growth trend assessments, by summing the expected values from the sub-regional models.

Results

The results of the 2013 survey indicate that the sea otter population in BC continued to grow and its distribution continued to expand since previouslt surveyed, with sub-regional population growth patterns that are typical of recovering sea otter populations. Annual growth rates were much lower in long occupied sub-regions of Vancouver Island and the central mainland coast, than in more recently occupied sub-regions, presumably reflecting density dependence.

Vancouver Island Region

In 2013, 5,612 sea otters were counted during surveys in the Vancouver Island region. The annual rate of increase over the region was 7.1% per year (*SE* = 1.05), during the period of 2009 to 2013 inclusive, and 6.8% per year (*SE* = 1.20) during the period 2004 to 2008. These growth estimates are not significantly different from each other. These trends are slightly lower than the 8.4% per year previously estimated for the period 1995 to 2008 (Nichol *et al.* 2009). The lower rates reflect the effect of density dependence in growth in the long occupied sub-regions, where logistic population models best fit the trends.

Near the centre of the Vancouver Island range, where the population has been established for the longest period of time (sub-regions 5 and 6), annual rates of increase were the lowest of all the sub-regions on Vancouver Islands in both the 2004 to 2008 and the 2009 to 2013 periods (Figure 2). In 2009 to 2013, the growth rate in sub-region 5 was 2.6% per year (*SE* = 0.66), and in sub-region 6, 2.5% per year (*SE* = 1.23). Rates of annual increase are higher among sub-regions to the north, but to the south are not as high as might be expected. In sub-region 7, the rate of annual increase from 2004 to 2013 was 8.9% per year, (*SE* = 1.82). This rate, although higher than the overall regional rate for Vancouver Island, seems low in an area that should represent the expanding southern edge of the range and an area that, according to habitat modelling, should have a lot of suitable habitat (Gregr *et al.* 2008). Range expansion by males into Clayoquot Sound was first recorded in 2004, followed by rafts of females in 2010, suggesting as much as a six-year interval between range expansion by males and the arrival by females.

Since 2008, range expansion events in the Vancouver Island region have occurred mainly in Queen Charlotte Strait and on the mainland shore (sub-region 1). In contrast, there has been less evidence of range expansion elsewhere on Vancouver Island, although rafts of male sea otters have been observed in Tahsis Inlet, as well as Esperanza Inlet, (sub-region 6) indicating that sea otters are now established around all of Nootka Island.

Central Mainland Coast Region

A total of 1,142 sea otters were counted in the occupied range in 2013, from Calvert Island to Aristizabal Island. The finite rate of growth for the region was estimate to be 12.6% per year (*SE* = 1.65) from 2009 to 2013 and 4.2% per year (*SE* = 1.62) from 2004 to 2008. The much higher growth rate estimate in the most recent five-year period, compared to the previous five-year period, reflects exponential growth from the two additional sub-regions of the central mainland coast, which have been occupied only since 2007 (Figure 3).

Range expansion to Calvert Island occurred after the surveys were completed in June 2013. Range expansion to Aristazabal Island was first documented during the survey in 2008. The expansion left a geographic gap in the range between the occupied range on the south side of Milbanke Sound and the occupied range at Aristazabal Island. The gap between these two areas persisted in 2013 and is likely attributable to variation in habitat quality, an explanation that has also been made to account for such gaps in the range of the southern sea otter in California. Historical reports of sea otters in inland passages[1] of BC, suggests gaps will be filled as prime habitat reaches carrying capacity densities. Indeed this may be occurring on Vancouver Island where occupation of inlet habitat such as Esperanza Inlet and Quatsino Sound by male rafts since 2001 may be an example of occupation of lesser quality habitat as a trade-off to maintain proximity to females.

[1] *Archibald Menzies, naturalist aboard the HMS* Discovery *in 1790 reported a sighting of a large raft of sea otters in Wright Sound which is northeast of Aristizabal Island at the entrance to Douglas Channel.*

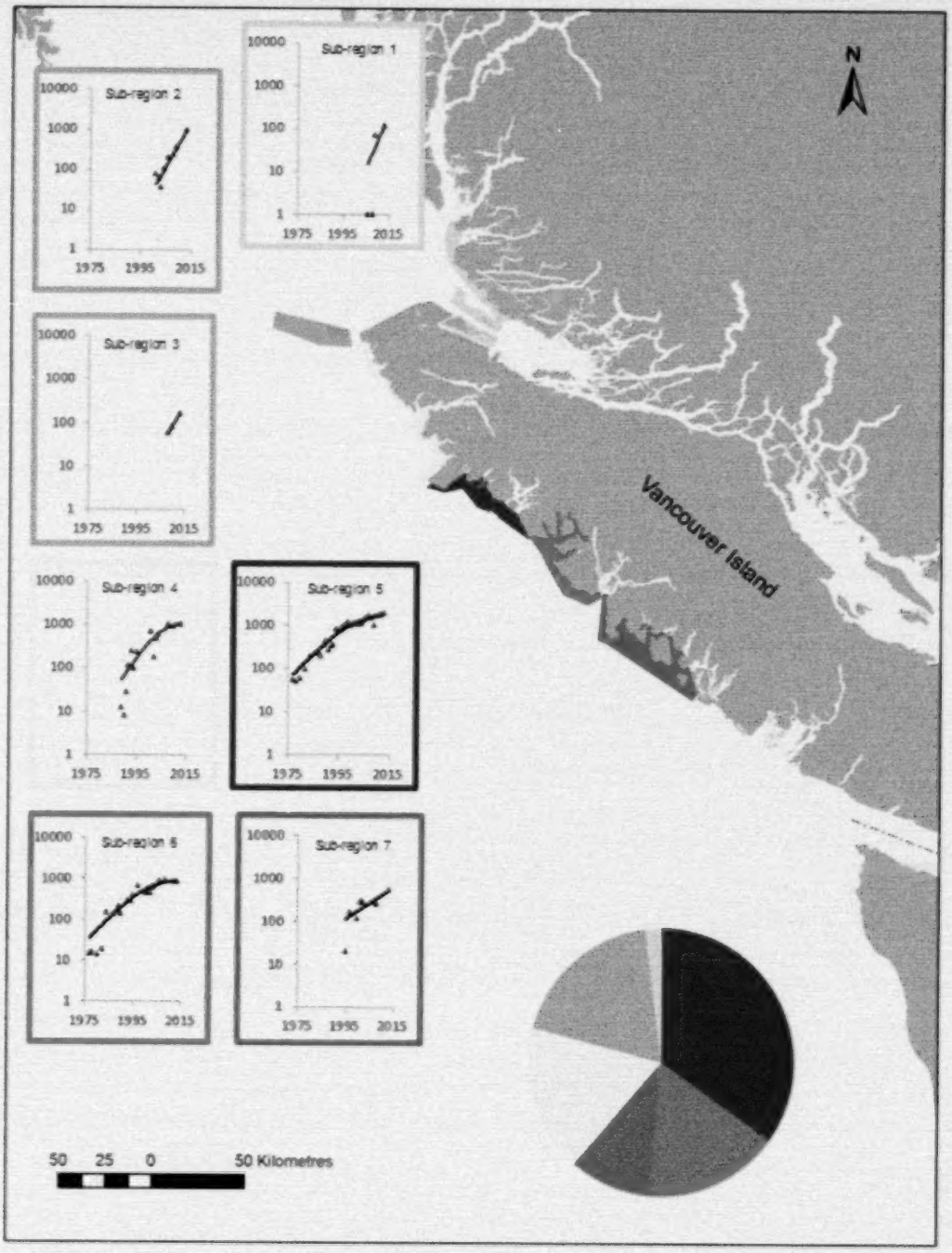

Figure 2. Estimated growth trends in the Vancouver Island region from 1977 to 2013. Inset graphs show growth curves by sub-region, either logistic or exponential (on a log scale) fitted to sea otter survey data. Inset pie chart gives the proportions of the 2013 count (5,612 sea otters) by sub-region.

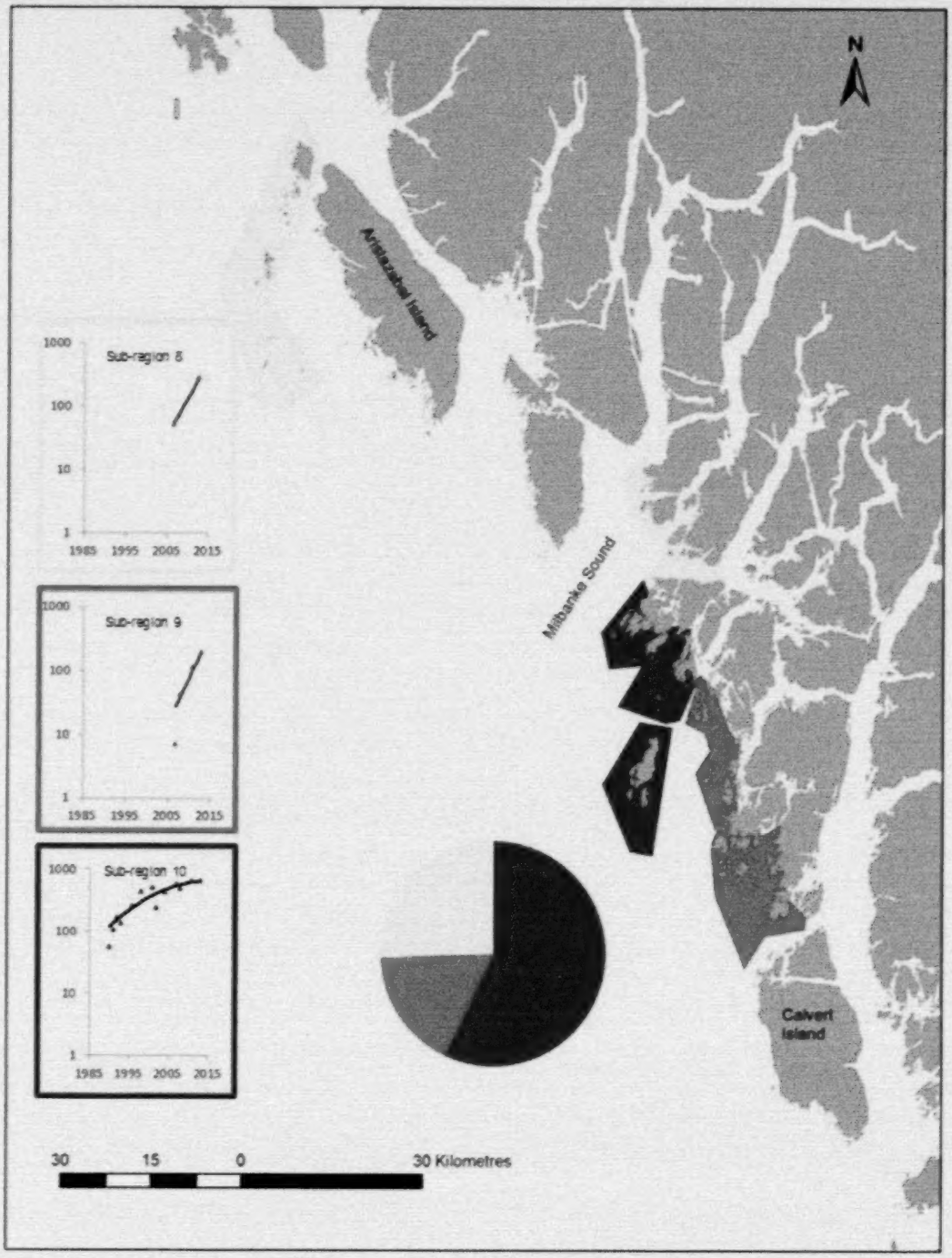

Figure 3. Estimated growth trends in the central mainland coast region 1990 to 2013. Inset graphs show growth curves by sub-regions either logistic or exponential (on log scale) fitted to sea otter survey data. Inset pie chart gives the proportions of the 2013 count (1,142 sea otters) by sub-region.

Sources of uncertainty

The survey counts provide an index of abundance, and it is assumed that among surveys a relatively constant proportion of the true population is counted, such that the trends in population growth are representative of processes in the sea otter population. In an effort to meet this assumption, surveys are conducted following the same routes and protocols among years, to hold constant the proportion of observer error among surveys. Previously, precision of replicate counts was assessed and it was determined that observer error could be as low as CV = 7–12% (Nichol *et al.* 2005).

The offshore transect count over Cook Bank at the northern end of Vancouver Island had not previously been made during surveys of sub-region 2. Therefore the number of sea otters that may have been missed in earlier years is unknown. The ship provided a higher and more stable platform and a wider field of view than would have been possible from a small boat. For these reasons, including the offshore transect count in the growth trend analysis may have inflated the growth rate estimate for northern Vancouver Island.

CONCLUSIONS

The sea otter population in BC has continued to grow and its distribution has continued to expand geographically into areas assumed to have historically been occupied by the species. The population is near carrying capacity in long occupied areas, but growth still fit an exponential population growth curve model in more recently occupied areas. These sub-regional patterns reflect the expected pattern of density dependent growth for this species.

Estimating growth using sub-regional data sets made it possible to use more years of survey data with which to estimate growth patterns within each region than in previous assessments.

Helicopter surveys are expensive and have not been possible in recent years, but maintaining a consistent level of survey effort with small boat surveys as the population continues to grow presents an on-going challenge. Further methodological development to address this challenge should be considered.

Further methodological development is also needed to develop a consistent approach to survey shallow, offshore features such as Cook Bank. Also of value would be the development of methods to incorporate variance associated with the survey counts into the survey design.

OTHER CONSIDERATIONS

There are no estimates of the number of the sea otters in the BC population prior to the maritime fur trade that commenced in 1778. However, historical records of pelt landings over certain periods and for certain areas in BC, suggest that there was a large population around Haida Gwaii (formerly the Queen Charlotte Islands) in the late 1700's, (an area not yet recolonized by sea otters). As many as 10,000 pelts a year were obtained in trade by American vessels trading with aboriginal peoples on the northern BC coast and in Southeast Alaska between 1790 and 1800.

Gregr *et al.* (2008) estimated the contemporary carrying capacity sea otter population for BC based on a habitat modeling approach. One model estimated a maximum population of 5,123 (95% CI=3,337–7,104) for the west coast of Vancouver Island in only high quality habitat and 14,831 (95% CI=9,790–20,751) coast-wide. A second model of the estimated coast-wide carrying capacity was, 52,459 sea otters (95% CI = 34,264–73,489). Coast-wide, the BC sea otter population is far below the estimates of both models.

SOURCES OF INFORMATION

This Science Advisory Report is from the Annual Meeting of the National Marine Mammal Peer Review Committee (NMMPRC) held in Ottawa October 20-24, 2014. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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Centre for Science Advice (CSA)
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, British Columbia V9T 6N7

Telephone: 250-756-7088
E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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